DECLARATION

I, the undersigned, of 15-29 Tsukamoto, 3-chome, Yodogawa-ku, Osaka 532-0026, JAPAN, hereby certify that I am well acquainted with the English and Japanese languages, that I am an experienced translator for patent matter, and that the attached document is a true English translation of

Japanese Patent Application No. 2000-100669.

I declare that all statements made herein of my own knowledge are true, that all statements on information and belief are believed to be true, and that these statements were made with the knowledge that willful statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code.

Signature:

Natsuko Honjo

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Dated: September 15, 2004

[Name of the Document] Specification

[Title of the Invention] Discharge lamp and lamp unit

[Claims]

[Claim 1] A discharge lamp comprising:

a luminous bulb in which a luminous material is enclosed and a pair of electrodes are opposed to each other in the luminous bulb; and

a pair of sealing portions for sealing a pair of metal foils electrically connected to the pair of electrodes, respectively,

wherein at least one of the pair of sealing portions is provided with at least one constricted part whose length in a thickness direction of the metal foil in the sealing portion is smaller as compared with other parts in the sealing portion.

[Claim 2] The discharge lamp of Claim 1, wherein said at least one constricted part is provided in a region of the sealing portion which is closer to the luminous bulb than a center of the sealing portion.

[Claim 3] The discharge lamp of Claim 1 or 2, wherein a plurality of the constricted parts are formed in the sealing portion.

[Claim 4] A discharge lamp comprising:

a luminous bulb in which a luminous material is enclosed and a pair of electrodes are opposed to each other in the

luminous bulb; and

a pair of sealing portions for sealing a pair of metal foils electrically connected to the pair of electrodes, respectively,

wherein at least one of the pair of sealing portions is provided with at least one oblate cross-sectional part in which a length in a direction perpendicular to a thickness direction of the metal foil in the sealing portion is larger than that in the thickness direction of the metal foil in the sealing portion.

[Claim 5] The discharge lamp of Claim 4, wherein a cross-sectional shape of the oblate cross-sectional part is a substantially elliptical shape having a minor axis in the thickness direction of the metal foil and a major axis in a direction perpendicular to the thickness direction.

[Claim 6] The discharge lamp of Claim 4 or 5, wherein the oblate cross-sectional part is provided in a region of the sealing portion which is closer to the luminous bulb than a center of the sealing portion.

[Claim 7] The discharge lamp of Claim 4 or 5, wherein the oblate cross-sectional part is formed in the entire sealing portion.

[Claim 8] The discharge lamp of any one of Claims 1 to 7, wherein each of the pair of sealing portions has a shrink seal structure.

[Claim 9] The discharge lamp of any one of Claims 1 to 8, wherein the ends of the pair of sealing portions at sides thereof opposite to the luminous bulb are tapered.

[Claim 10] The discharge lamp of any one of Claims 1 to 9, wherein each of the pair of metal foils is pressed and attached to a glass portion extended from the luminous bulb, and

each of the pair of metal foils is a molybdenum foil.

[Claim 11] The discharge lamp of any one of Claims 1 to 10, wherein the luminous material contains at least mercury.

[Claim 12] A lamp unit comprising: the discharge lamp of any one of Claims 1 to 11; and a reflecting mirror for reflecting light emitted from the discharge lamp.

[Detailed Description of the Invention]

[Technical Field to which the Invention Belongs]

The present invention relates to a discharge lamp and a lamp unit. In particular, a discharge lamp and a lamp unit used as a light source for an image projection apparatus such as a liquid crystal projector and a digital micromirror device (DMD) projector.

[Prior Art]

In recent years, an image projection apparatus such as a liquid crystal projector and a DMD projector has been widely used as a system for realizing large-scale screen images, and a high-pressure discharge lamp having a high intensity has

been commonly and widely used in such an image projection apparatus. In the image projection apparatus, its light source is required to have a proximity to a point light source in addition to a high intensity since light needs to be concentrated on a very small area of a liquid crystal panel or the like. Therefore, among high-pressure discharge lamps, a short arc type ultra high-pressure mercury lamp having the advantages of a higher proximity to a point light source and a high intensity has been attracting much attention as a promising light source.

Referring to FIGS. **8(a)** through **8(c)**, a conventional short arc type ultra high-pressure mercury lamp **1000** will be described.

FIG. **8(a)** schematically illustrates the top of the lamp **1000**, and FIG. **8(b)** schematically illustrates the side of the lamp **1000**. FIG. **8(c)** illustrates the cross-section taken along the line c-c′ of FIG. **8(a)**.

The lamp **1000** includes a substantially spherical luminous bulb **110** made of quartz glass, and a pair of sealing portions **120** and **120′** (seal portions) that are made of quartz glass likewise and connected to the luminous bulb **110**. A discharge space **115** is inside the luminous bulb **110**. Mercury **118** in an amount of the enclosed mercury of, for example, 150mg/cm^3 to 250mg/cm^3 as a luminous material, a rare gas (e.g., argon with several tens kPa), and a small

amount of halogen are enclosed in the discharge space **115.**

A pair of tungsten electrodes (W electrodes) **112** and **112′** are opposed to each other with a certain gap interposed therebetween in the discharge space **115,** and a coil **114** is wound around the end of the electrode **112** (or **112′**). An electrode axis **116** of the W electrode **112** is welded to a molybdenum foil (Mo foil) **124** in the sealing portion **120,** and the W electrode **112** and the Mo foil **124** are electrically connected by a welded portion **117** where the electrode axis **116** and the Mo foil **124** are welded.

The sealing portion **120** includes a glass portion **122** extended from the luminous bulb **110** and the Mo foil **124,** and the cross-sectional shape of the sealing portion **120** is circular as shown in FIG. **8(c).** In the sealing portion **120,** the glass portion **122** and the Mo foil **124** are pressed and attached to each other, thereby maintaining the airtightness in the discharge space **115** in the luminous bulb **110.** A brief description will be below described about the principle that the luminous bulb **110** can be sealed by the sealing portion **120.**

Since the thermal expansion coefficient of the quartz glass constituting the glass portion **122** is different from that of the molybdenum constituting the Mo foil **124,** the glass portion **122** and the Mo foil **124** will not be integral, but the gap created between the Mo foil **124** and the glass

portion **122** can be filled by plastically deforming the Mo foil **124**. Thus, the Mo foil **124** and the glass portion **122** are pressed and attached to each other, and the luminous bulb **110** can be sealed with the sealing portion **120**. In other words, the sealing portion **120** is sealed with metal foil by pressing and attaching the Mo foil **124** to the glass portion **122**. It should be noted that, since the glass portion **122** and the electrode axis **116** of the W electrode **112** are not pressed and attached to each other, a gap (not shown) is created between the glass portion **122** and the electrode axis **116** due to a difference in the thermal expansion coefficient.

The Mo foil **124** attached tightly to the glass portion **122** of the sealing portion **120** has a rectangular plane shape and is positioned in the center of the sealing portions **120** and **120'** as shown in FIG. **8(c)**. The Mo foil **124** includes, at the side thereof opposite to the other side thereof where the welded portion **117** is positioned, an external lead (Mo rod) **130** made of molybdenum. The Mo foil **124** and the external lead **130** are welded to each other, and therefore, the Mo foil **124** and the external lead **130** are electrically connected at a welded portion **132**. The external lead **130** is electrically connected to a member (not shown) positioned in the periphery of the lamp **1000**.

Next, the operational principle of the lamp **1000** will be briefly described. When a starting voltage is applied to the

W electrodes **112** and **112'** via the external leads **130** and the Mo foils **124**, discharge of argon (Ar) occurs, and then this discharge raises the temperature in the discharge space **115** of the luminous bulb **110**, thus heating and evaporating the mercury **118**. Thereafter, mercury atoms are excited and become luminous in the arc center between the W electrodes **112** and **112'**. The higher the vapor pressure of the mercury in the lamp **1000**, the higher the luminous efficacy, and therefore, the higher the vapor pressure of the mercury, the more suitable the lamp **1000** for an image projection apparatus as a light source. However, in view of the physical strength of the luminous bulb **110** to withstand pressure, the lamp **1000** is used at a mercury vapor pressure between 15MPa and 25MPa.

[Problems that the Invention is to solve]

As a result of in-depth research, the inventors of the present invention have found that there arises a problem in the conventional lamp **1000** that the sealing structure of the sealing portion **120** is destroyed to shorten the lifetime of the lamp.

More specifically, since the cross-sectional shape of the sealing portion **120** of the lamp **1000** is circular, the length of the sealing portion **120** in the thickness direction is constant (in other words, the thickness of the glass portion **122** of the sealing portion **120** is constant). In addition, since the sealing portion **120** is sealed by pressing

and attaching the Mo foil **124** to the glass portion **122,** as shown in FIGS. **9(a)** and **9(b),** internal stress **40** (from the glass portion **122**) is applied uniformly to the Mo foil **124** in the direction perpendicular to the surface of the foil (the **Z** direction in the drawings). For this reason, as shown in FIG. **9(c),** if expansion and contraction of the Mo foil **124** are repeated with use of the lamp **1000,** a gap **119** that exists between a part of the glass portion **122** on the discharge bulb **110** side and the electrode axis **116** will proceed in the direction shown by an arrow **119a** (i.e., the longitudinal direction of the Mo foil **124**) between the glass portion **122** and the Mo foil **124** that are simply pressed and attached to each other. Once the gap **119** has proceeded to reach the welded portion **132** between the Mo foil **124** and the external lead **130,** the entire Mo foil **124** is oxidized, the conductivity of the Mo foils **124** is lost, and therefore, the lamp **1000** may stop its operation.

Furthermore, in response to reduction in lamp size associated with miniaturization of image projection apparatuses, reduction in size of the sealing portion **120** is in demand. If the size of the sealing portion **120** is reduced according to the demand, as shown in FIG. **9(b),** the thickness **T** of the glass between the side face **124a** of the Mo foil **124** and the surface **122a** of the glass portion **122** becomes small; therefore, a crack **45** proceeding from the side face **124a** of

the Mo foil **124** reaches the surface **122a** of the glass portion **122**, thus causing a problem that the sealing structure of the sealing portion **120** is destroyed.

The present invention has been made in view of the above problems and its main object is to provide a discharge lamp that can maintain the sealing structure of the sealing portions for a long period, resulting in an elongated lifetime.

[Means for Solving the Problems]

A discharge lamp of the present invention includes: a luminous bulb in which a luminous material is enclosed and a pair of electrodes are opposed to each other in the luminous bulb; and a pair of sealing portions for sealing a pair of metal foils electrically connected to the pair of electrodes, respectively, wherein at least one of the pair of sealing portions is provided with at least one constricted part whose length in a thickness direction of the metal foil in the sealing portion is smaller as compared with other parts in the sealing portion.

It is preferable that said at least one constricted part is provided in a region of the sealing portion which is closer to the luminous bulb than a center of the sealing portion.

It is preferable that a plurality of constricted parts are formed in the sealing portion.

Another discharge lamp according to the present invention includes: a luminous bulb in which a luminous material is enclosed and a pair of electrodes are opposed to each other in the luminous bulb; and a pair of sealing portions for sealing a pair of metal foils electrically connected to the pair of electrodes, respectively, wherein at least one of the pair of sealing portions is provided with at least one oblate cross-sectional part in which a length in a direction perpendicular to a thickness direction of the metal foil in the sealing portion is larger than that in the thickness direction of the metal foil in the sealing portion.

In one embodiment, the cross-sectional shape of the oblate cross-sectional part is a substantially elliptical shape having a minor axis in the thickness direction of the metal foil and a major axis in a direction perpendicular to the thickness direction.

It is preferable that the oblate cross-sectional part is provided in a region of the sealing portion which is closer to the luminous bulb than a center of the sealing portion.

It is preferable that the oblate cross-sectional part is formed in the entire sealing portion.

It is preferable that each of the pair of sealing portions has a shrink seal structure.

It is preferable that the ends of the pair of sealing portions at sides thereof opposite to the luminous bulb are

tapered.

In one embodiment, each of the pair of metal foils is pressed and attached to a glass portion extended from the luminous bulb, and each of the pair of metal foils is a molybdenum foil. In one embodiment, the luminous material contains at least mercury.

A lamp unit of the present invention includes: the discharge lamp; and a reflecting mirror for reflecting light emitted from the discharge lamp.

Hereinafter, the functions of the present invention will be described.

In a discharge lamp of the present invention, since constricted part whose length in the thickness direction of the metal foil is smaller as compared with other parts in the sealing portion is formed in the sealing portion, the internal stress applied (from the glass portion) to the surface of the metal foil in the constricted part of the sealing portion can be smaller than that in the other parts of the sealing portion. For this reason, the internal stress from the metal foil in the constricted part can be relatively larger compared with the other parts, and therefore, the metal foil can be deformed (thermally expanded) selectively in the constricted part. As a result, the metal foil in the constricted part can stop the gap from proceeding in the sealing portion, thus maintaining the sealing structure of

the sealing portion for a long time as compared with the prior art. By providing the constricted part in the region of the sealing portion which is closer to the luminous bulb than the center of the sealing portion, the proceeding of the gap in the sealing portion can be stopped more effectively. It is preferable to form a plurality of the constricted parts because the proceeding of the gap in the sealing portion can be stopped in a plurality of points.

In another discharge lamp of the present invention, an oblate cross-sectional part in which the length in the direction perpendicular to the thickness direction of the metal foil in the sealing portion is larger than that in the thickness direction of the metal foil is formed in the sealing portion, thus making it more difficult for a crack proceeding from the side face of the metal foil to reach the surface of the sealing portion as compared with the prior art. As a result, the sealing structure of the sealing portion can be maintained for a longer time as compared with the prior art. The cross-sectional shape of the oblate cross-sectional part may be, for example, a substantially elliptical shape having its minor axis in the thickness direction of the metal foil and its major axis in the direction perpendicular to the thickness direction. Cracks are likely to occur in the sealing portion at the side of the luminous bulb where the temperature is changed significantly;

therefore, if the oblate cross-sectional part is provided in the region of the sealing portion closer to the luminous bulb than the center of the sealing portion, the sealing structure of the sealing portion can be effectively prevented from being destroyed by cracks. Furthermore, for example, the cross-sectional shape of the entire sealing portion may be a substantially elliptical shape so that the entire sealing portion may be formed by the oblate cross-sectional part.

It is preferable that each of the pair of sealing portions has the shrink seal structure in view of the improvement of its resistance to pressure. As an exemplary discharge lamp of the present invention, there is a mercury lamp (including ultra high-pressure mercury lamp, high-pressure mercury lamp, and low-pressure mercury lamp) containing at least mercury as a luminous material. The discharge lamp of the present invention may be formed in combination with a reflecting mirror for reflecting light emitted from the discharge lamp to form a lamp unit.

[Embodiments of the Invention]

Hereinafter, embodiments of the present invention will be described with reference to the drawings. In the following drawings, for the sake of simplicity of the description, the elements having substantially the same functions are identified by the same reference characters.

(Embodiment 1)

A discharge lamp **100** according to Embodiment **1** of the present invention will be described with reference to FIGS. **1** through **4**.

First, FIG. **1** is referred to. FIG. **1(a)** schematically illustrates the top of the discharge lamp **100** according to this embodiment, and FIG. **1(b)** schematically illustrates the side of the discharge lamp **100**. FIG. **1(c)** illustrates the cross-section taken along the line c-c′ of FIG. **1(a)**. And FIG. **1(d)** schematically illustrates the shape of an end face of a metal foil **24** in an enlarged manner. It should be noted that the arrows **X**, **Y**, and **Z** in the drawings show the coordinate axes.

The discharge lamp **100** of Embodiment **1** includes a luminous bulb (bulb) **10** and a pair of sealing portions **20** and **20′** connected to the luminous bulb **10**.

A discharge space **15** in which a luminous material **18** is enclosed is provided inside the luminous bulb **10**, and a pair of electrodes **12** and **12′** are opposed to each other in the discharge space **15**. The luminous bulb **10** is made of quartz glass and is substantially spherical. The outer diameter of the luminous bulb **10** is, for example, between about 5mm and about 20mm, and the glass thickness of the luminous bulb **10** is, for example, between about 1mm and about 5mm. The volume of the discharge space **15** in the luminous bulb **10** is, for example, between about 0.01cc and about 1.0cc. In this

embodiment, the luminous bulb **10** having an outer diameter of about 13mm, a glass thickness of about 3mm, and a volume of the discharge space **15** of about 0.3cc is used, and mercury is used as the luminous material **18**. For example, about 150mg/cm^3 to 200mg /cm^3 of mercury, a rare gas (e.g., argon) with 5kPa to 20kPa, and a small amount of halogen are enclosed in the discharge space **15**. It should be noted that, in FIG. **1(a)** and FIG. **1(b)**, the mercury **18** adhered to the inner wall of the luminous bulb **10** is schematically shown.

The pair of electrodes **12** and **12′** in the discharge space **15** are arranged with a gap (arc length) of, for example, between about 1mm and about 5mm interposed therebetween. As the electrodes **12** and **12′**, for example, tungsten electrodes (W electrodes) are used. In this embodiment, the W electrodes **12** and **12′** are arranged with a gap of about 1.5mm interposed therebetween. A coil **14** is wounded around the end of each of the electrodes **12** and **12′**. The coil **14** has a function of lowering the temperature of the electrode end. An electrode axis (W rod) **16** of the electrode **12** is electrically connected to the metal foil **24** in the sealing portion **20**. Similarly, an electrode axis **16** of the electrode **12′** is electrically connected to the metal foil **24′** in the sealing portion **20′**.

The sealing portion **20** includes a metal foil **24** electrically connected to the electrode **12** and a glass

portion **22** extended from the luminous bulb **10**, and the airtightness in the discharge space **15** in the luminous bulb **10** is maintained by sealing of the glass portion **12** with metal foil, i.e., the metal foil **24**. The metal foil **24** is a molybdenum foil (Mo foil), for example, and has a rectangular shape, for example. The glass portion **22** is made of quartz glass, for example.

As shown in FIG. **1(d)**, the thickness **d** of the metal foil **24** is, for example, between about 20 μm and about 30 μm, the width **w** of the metal foil **24** is, for example, between about 1.5mm and about 2.5mm, and the ratio of the thickness **d** to the width **w** is about 1: 100. In this embodiment, as shown in FIG. **1(d)**, the side of the metal foil **24** is sharp. The reasons for this design are that a gap is prevented from being created between the metal foil **24** and the glass portion **22** and that the internal stress occurring perpendicularly to the side face of the metal foil **24** is prevented, as much as possible, from being directed to a direction **x** (**X** direction) perpendicular to the thickness direction of the foil, thus preventing, as much as possible, cracks from occurring in the direction **x** (**X** direction) perpendicular to the thickness direction.

It is preferable that the sealing portion **20** is formed to have a shrink seal structure. This is because when the sealing portion of shrink seal structure is produced, the

glass tube is heated, sealed, and then cooled spontaneously; therefore, the residual stress (strain) can be prevented from occurring in the glass portion **22** of the sealing portion **22**, resulting in improved resistance of the sealing structure to pressure. The metal foil **24** in the sealing portion **20** is joined to the electrode **12** by welding, and the metal foil **24** includes an external lead **30** at the side thereof opposite to the other side thereof where the electrode **12** is joined. The external lead **30** is made of, for example, molybdenum. It should be noted that the sealing portion **20'** has the same structure as that of the sealing portion **20**, and therefore, further description will be omitted.

At least one constricted part **26** is formed in at least one sealing portion **20** of the pair of sealing portions. The constricted part **26** is the part whose length in the thickness direction (**Z** direction) of the metal foil **24** of the sealing portion **20** is smaller than that of other parts of the sealing portion **20** (e.g., a part adjacent to the constricted part **26**). In other words, in the constricted part **26**, the thickness of the glass portion **22** in the thickness direction of the metal foil **24** is smaller than that of the other parts. As shown in FIG. **1(b)**, the constricted part **26** is recessed deeper than the parts adjacent to the constricted part **26**, and the length **L'** of the constricted part **26** in the thickness direction (**Z** direction) is shorter than the length **L** of the

other parts in the sealing portion **20**. The length **L'** of the constricted part **26** in the thickness direction may be, for example, between about 70% and about 90% of the length **L** of the other parts in the thickness direction.

In the area of the sealing portion **20** in which the metal foil **24** is disposed, the constricted part **26** is a part where the contour of the sealing portion **20** is recessed and then the length in the thickness direction increases from that of the recessed section; therefore, as shown in FIG. **1(c)**, when the cross-sectional shapes of the sealing portion **20** and the constricted part **26** are circular, the outer diameter of the constricted part **26** is smaller as compared with the other parts.

In this embodiment, the outer diameter of the constricted part **26** is, for example, about 7mm, and the outer diameter of the parts other than the constricted part **26** is, for example, about 8mm. In order to make it difficult for cracks proceeding from the side face **24c** of the metal foil **24** to reach the surface **26a** of the constricted part **26**, it is preferable that the thickness **T** of the glass portion **22** from the side face **24c** of the metal foil **24** to the surface **26a** of the constricted part **26** is, for example, about 2mm or more. It should be noted that the cross-sectional shape of the constricted part **26** is not limited to a circle but it may be, for example, a substantially elliptical shape. Furthermore,

the discharge lamp **100** of this embodiment is formed so that one sealing portion **20** has one constricted part **26** and the other sealing portion **20′** has a plurality of constricted parts **26**.

Next, FIG. **2** is referred to. FIGS. **2(a)** and **2(b)** schematically show the constricted part **26** of the sealing portion **20** in an enlarged manner.

As shown in FIG. **2(a)**, when the sealing portion **20** has the constricted part **26**, an internal stress **40** applied perpendicularly from the glass portion **22** to the metal foil **24** can be smaller in the constricted part **26** compared with the other parts. This is because, the thickness of the glass portion **22** in the constricted part **26** is smaller than that of the glass portion **22** in the other parts, resulting in smaller stress applied from the glass portion **22** to the metal foil **24** than that from the glass portion **22** in the other parts. Therefore, as shown in FIG. **2(b)**, since an internal stress **40′** applied from the metal foil **24** to the glass portion **22** becomes relatively large in the constricted part **26** compared with the other parts, the metal foil **24** is deformed as shown by an arrow **24d** to create an expanded part **24e** in the metal foil **24** in the constricted part **26**. As a result, the expanded part **24e** of the metal foil **24** can stop a gap **19** from proceeding in the direction of an arrow **19a**, thereby preventing the entire metal foil **24** from being oxidized. In

other words, the sealing structure of the sealing portion can be maintained for a longer time compared with the prior art by allowing the metal foil **24** positioned in the constricted part **26** to function as a part **24e** for stopping the gap from proceeding.

As shown in FIGS. **1(a)** and **1(b)**, since the proceeding of the gap **19** starts at the luminous bulb **10** side, it is preferable to form the constricted part **26** at the side of the sealing portion **20** connected to the luminous bulb **10** with respect to the center of the sealing portion **20**, thus stopping the proceeding of the gap **19** at an earlier stage. Furthermore, it is more preferable to form a plurality of constricted parts **26** as in the sealing portion **20'** because the proceeding of the gap **19** can be stopped at a plurality of points.

It should be noted that, in this embodiment, both the pair of sealing portions are so formed as to have the constricted part **26**, but if at least one sealing portion has the constricted part **26**, the proceeding of the gap **19** can be stopped, thereby maintaining the sealing structure of the sealing portion for a longer time compared with the prior art. For example, when the discharge lamp **100** is set to a reflecting mirror, it may also be arranged so that the constricted part **26** is formed only in the sealing portion at the side thereof in the direction to which light is emitted

(at the side of the front opening of the reflecting mirror) where drastic temperature change occurs.

Next, a method for producing the discharge lamp **100** will be exemplified with reference to FIG. **3**. FIGS. **3(a)** to **3(c)** are cross-sectional views showing each process step in a method for producing the discharge lamp **100**.

First, as shown in FIG. **3(a)**, the metal foil (Mo foil) **24** having the electrode **12** and the external lead **30** is inserted in a glass pipe for a discharge lamp having a portion to be the luminous bulb **10** and a portion to be the glass portion **22** of the sealing portion (electrode insertion process).

Then, as shown in FIG. **3(b)**, the pressure in the glass pipe is reduced (to, e.g., one atmospheric pressure or less), and the glass tube **22** is heated and softened, for example, with a burner **50** to attach the glass tube **22** tightly to the metal foil **24**, thus forming the sealing portion **20** (sealing portion formation process). At this time, if the sealing portion **20** is pulled in the direction of the arrow **52** while the metal foil **24** and the glass tube **22** (glass portion of the sealing portion **20**) are not tightly attached to each other yet, a constriction is formed in the glass portion **22**, thereby forming the constricted part **26** in the sealing portion **20** as shown in FIG. **3(c)** (constricted part formation process). In this manner, the discharge lamp **100** provided

with the sealing portion **20** having the constricted part **26** can be produced. It should be noted that if the glass tube **22** is heated and softened while the glass tube **22** is standing, the glass tube **22** is extended by the weight of the glass tube **22** itself, thereby easily forming the constricted part **26**.

Furthermore, as shown in FIG. **4**, after the constricted part formation process, the glass portion **22** may be further processed to produce a discharge lamp **200** in which an end **20a** of the sealing portion **20** is tapered. If the end **20a** of the sealing portion **20** is tapered, the angle of the edge of the end **20a** is changed from 90 degrees to an obtuse angle; therefore, in the process of handling a plurality of discharge lamps (for example, in a washing process or the like), the edge of the end **20a** of a discharge lamp is prevented from physically destroying a part of another discharge lamp (e.g., the glass portion **22** of the sealing portion **20**), or that possibility is reduced. The taper angle **θ** of the end **20a** of the sealing portion **20** may be, for example, between about 45 degrees and 60 degrees.

In order to produce the tapered end **20a**, for example, the glass portion **22** may be ground with a grinder **44** while the glass pipe that has been subjected to the constricted part process is rotated in the direction of the arrow **46**. After the glass portion **22** has been ground, the ground part

of the glass is broken, for example, by hand with a care not to break the external lead **30**, and an unnecessary portion **23** is removed, thus obtaining the discharge lamp **200**.

In the discharge lamp of this embodiment, at least one of the pair of sealing portions has the constricted part **26**, and the metal foil **24** positioned in the constricted part **26** is allowed to function as the part **24e** for stopping the gap from proceeding. As a result, the sealing structure of the sealing portion can be maintained for a longer time as compared with the prior art.

(Embodiment **2**)

A discharge lamp **300** according to Embodiment **2** of the present invention will be described with reference to FIG. **5**. The discharge lamp **300** of this embodiment is different, in that an oblate cross-sectional part is formed in the sealing portion, from the discharge lamp **100** of Embodiment **1** in which the constricted part **26** is formed in the sealing portion. It should be noted that, for the simplification of description of this embodiment, the points different from Embodiment **1** will be mainly described in the following description, and the description of the same points as those in Embodiment **1** is either omitted or simplified.

FIG. **5(a)** schematically illustrates the top of the discharge lamp **300** of this embodiment, and FIG. **5(b)** schematically illustrates the side of the discharge lamp **300**.

FIG. **5(c)** illustrates the cross-section taken along the line c-c′ of FIG. **5(a)**.

The discharge lamp **300** of this embodiment includes a luminous bulb **10** and a pair of sealing portions **20** and **20′** connected to the luminous bulb **10**, and at least one oblate cross-sectional part **28** is formed in at least one of the pair of sealing portions **20** and **20′**. The oblate cross-sectional part **28** is the part in which the length **L1** in the direction **x** (or the **X** direction in the drawings) perpendicular to the thickness direction of the metal foil **24** in the sealing portion **20** is larger than the length **L2** in the thickness direction (the **Z** direction in the drawings). In this embodiment, the entire sealing portion **20** (or **20′**) is formed by the oblate cross-sectional part **28**, and as shown in FIG. **5(c)**, the sealing portion **20** is formed so that the cross-sectional shape of the oblate cross-sectional part **28** is substantially elliptical. In other words, the oblate cross-sectional part **28** having the substantially elliptical shape in which its minor axis **28b** is positioned in the thickness direction of the metal foil **24** and its major axis **28a** is positioned in the direction **x** perpendicular to the thickness direction is formed in the entire sealing portion **20**.

When the sealing portion **20** has the oblate cross-sectional part **28**, the thickness **T** of the glass portion **22** from the side face **24c** of the metal foil **24** to the surface

28c of the oblate cross-sectional part **28** can be larger than that of the glass portion in a conventional discharge lamp having the same size. For this reason, it is possible to make it difficult for cracks proceeding from the side face **24c** of the metal foil **24** to reach the surface **28c** of the oblate cross-sectional part **28**. As a result, the sealing structure of the sealing portion can be maintained for a longer time as compared with the prior art.

Furthermore, compared with the case where the cross-section of the sealing portion **20** is formed to be circular, the ratio of the length **L2** in the thickness direction to the length **L1** in the direction **x** perpendicular to the thickness direction can be reduced, thereby making the internal stress applied from the glass portion **22** to the upper and lower surfaces of the metal foil **24** relatively small. Thus, the metal foil **24** is more likely to be deformed in the thickness direction, and the internal stress of the metal foil **24** can be stronger in the thickness direction. As a result, the internal stress applied from the side face **24c** of the metal foil **24** to the glass portion **22** (internal stress from the metal foil **24** in the direction **x** perpendicular to the thickness direction) can be smaller than that of the case of the circular cross-section. Therefore, in the case of the sealing portions **20** having the same thickness **T** of the glass portion **22** from the side face **24c** of the metal foil **24** to the

surface **28c** of the oblate cross-sectional part **28,** the substantially elliptical sealing portion **20** of this embodiment can maintain the sealing structure for a longer time than the sealing portion having a circular cross-section.

In this embodiment, as shown in FIG. **5(c)**, the oblate cross-sectional part **28** is formed to have a cross-section having its minor axis **28b** positioned in the thickness direction of the metal foil **24** (**Z** direction in the drawing) and its major axis **28a** positioned in the direction perpendicular to the thickness direction (**X** direction in the drawing). The ratio of the length (**L1**) of the major axis **28a** to the length (**L2**) of the minor axis is, for example, 2:1. Also, when **L1** is about 16mm and **L2** is about 8mm, the glass portion **22** is formed so that the thickness **T** thereof from the side face **24c** of the metal foil **24** to the surface **28c** of the oblate cross-sectional part **28** is about 6mm.

Furthermore, even if the oblate cross-sectional part is not formed in the entire sealing portion **20,** the sealing structure of the sealing portion **20** can be maintained for a longer time compared with the prior art as long as the oblate cross-sectional part **28** is formed in at least a part of the sealing portion **20.** During the operation of the lamp, a temperature change in the metal foil **24** is larger in the part of the sealing portion close to the luminous bulb **10** than in

the part of the sealing portion away from the luminous bulb **10**, and therefore, deformation (thermal expansion) of the metal foil occurring due to a temperature change is greater at the luminous bulb **10** side. As a result, cracks are likely to occur in the glass portion **22** at the luminous bulb **10** side. Therefore, when the oblate cross-sectional part **28** is formed in a part of the sealing portion **20**, it is preferable to form the oblate cross-sectional part **28** in the sealing portion **20** at the luminous bulb **10** side from its center. It should be noted that the constricted part **26** of Embodiment **1** may be formed to be the oblate cross-sectional part **28**, or the constricted part **26** and the oblate cross-sectional part **28** may be formed independently in the sealing portion **20**.

It should be noted that, in this embodiment, both the pair of sealing portions are formed to have the oblate cross-sectional part **28**, but if at least one of the pair of sealing portions has the oblate cross-sectional part **28**, the sealing structure of the sealing portion may be maintained for a longer time compared with the prior art.

Next, a method for producing the discharge lamp **300** will be exemplified. To obtain the discharge lamp **300**, after the electrode insertion process (FIG. **3(a)**) of Embodiment **1** has been performed, the sealing portion formation process (FIG. **3(b)**) may be performed so that the length **L1** of the direction (**X** direction) perpendicular to the thickness direction is

larger than the length **L2** of the thickness direction (**Z** direction). Hereinafter, the method will be described more specifically with reference to FIG. **6**.

First, a glass pipe for a discharge lamp is disposed in a vertical direction (the **Y** direction in the drawing), and then the upper portion and the lower portion of the glass pipe are supported with a chuck (not shown) so that the glass pipe can be rotated in the direction of the arrows **41**. Next, the metal foil **24** having the electrode **12** and the external lead **30** is inserted in the glass pipe, and then the inside of the glass pipe is put to be ready for pressure reduction. Then, after the pressure inside the glass pipe has been reduced (to, e.g., 20kPa) and the glass pipe has been rotated in the direction shown by the arrows **41**, the glass tube **22** is heated and softened by, for example, a burner **50**.

In this case, if the metal foil **24** and the glass tube **22** are tightly attached to each other while the rotation of the glass pipe is temporarily stopped or the rotational speed is adjusted to change the heating state between the glass portion **22** positioned in the thickness direction of the metal foil **24** and the glass portion **22** positioned in the direction (**X** direction) perpendicular to the thickness direction, the oblate cross-sectional part **28** can be formed in the sealing portion **20**. In this embodiment, the oblate cross-sectional part **28** is formed by temporarily stopping the rotation of the

glass pipe in the position where the surface of the metal foil **24** faces the burner **50** (the rotation is stopped at every 180°). Alternatively, a desired portion of the glass tube **22** may be heated and softened by rotating the burner **50** without rotating the glass pipe.

In the discharge lamp of this embodiment, the sealing portion **20** has the oblate cross-sectional part **28**, and it is possible to make it more difficult for cracks proceeding from the side face **24c** of the metal foil **24** to reach the surface of the sealing portion **20** as compared with the prior art. As a result, the sealing structure of the sealing portion can be maintained for a longer time as compared with the prior art.

(Embodiment **3**)

The discharge lamps of Embodiments **1** and **2** can be combined with a reflecting mirror to form a lamp unit. FIG. **7** schematically illustrates the cross-section of a lamp unit **500** including the discharge lamp **100** of Embodiment **1**.

The lamp unit **500** is provided with the discharge lamp **100** including a substantially spherical luminous portion **10** and a pair of sealing portions **20**, and a reflecting mirror **60** for reflecting light emitted from the discharge lamp **100**. It should be noted that the discharge lamp **100** is only illustrative, and any one of the discharge lamps of the above embodiments may be used.

The reflecting mirror **60** is designed to reflect the

radiated light from the discharge lamp **100** so that the light becomes, for example, a parallel luminous flux, a condensed luminous flux converged on a predetermined small area, or a divergent luminous flux equal to that emitted from a predetermined small area. As the reflecting mirror **60**, a parabolic reflector or an ellipsoidal reflector, for example, may be used.

In this embodiment, a lamp base **55** is attached to one sealing portion **20** of the discharge lamp **100**, and the external lead **30** extending from the sealing portion **20** and the lamp base **55** are electrically connected. The sealing portion **20** at the side thereof where the lamp base **55** is attached is adhered to the reflecting mirror **60**, for example, with an inorganic adhesive (e.g., cement) so that they are integral with each other. A lead wire **65** is electrically connected to the external lead **30** of the sealing portion **20** positioned at the front opening side **60a** of the reflecting mirror **60**, and the lead wire **65** extends from the external lead **30** to the outside of the reflecting mirror **60** through an opening **62** for a lead wire of the reflecting mirror **60**. For example, a front glass may be attached to the front opening **60a** of the reflecting mirror **60**.

Such a lamp unit may be attached to an image projection apparatus such as a projector employing liquid crystal or DMD and may be used as the light source for the image projection

apparatus. The discharge lamp and the lamp unit of the above embodiments may be used not only as the light source for image projection apparatuses but also as a light source for ultraviolet steppers, a light source for a stadium, a light source for headlights of automobiles, or the like.

(Other embodiment)

In the above embodiments, mercury lamps employing mercury as the luminous material have been described as an example of the discharge lamp, but the present invention is also applicable to any discharge lamp having a structure in which the airtightness of the luminous bulb is maintained by the sealing portion (seal portion). For example, the present invention can also be applied to a discharge lamp enclosing a metal halide such as a metal halide lamp.

Further, the above embodiments have been described on the supposition that the mercury vapor pressure is about 20MPa (in the case of so-called ultra high-pressure mercury lamps), but the present invention can also be applied to a high-pressure mercury lamp in which the mercury vapor pressure is about 1 MPa, or a low-pressure mercury lamp in which the mercury vapor pressure is about 1 kPa. Furthermore, the gap (arc length) between the pair of electrodes **12** and **12′** may be of short arc type, or may be longer than that. The discharge lamps of the above embodiments can be used by any lighting method, either

alternating current lighting or direct current lighting.

[Effects of the Invention]

In a discharge lamp of the present invention, at least one of a pair of sealing portions has the constricted part, and therefore, the sealing structure of the sealing portion can be maintained for a long time, resulting in elongated lifetime of the lamp. Also, in another discharge lamp of the present invention, at least one of a pair of sealing portions has the oblate cross-sectional part, and therefore, the sealing structure of the sealing portion can be maintained for a long time, resulting in elongated lifetime of the lamp.

[Brief Explanation of the Drawings]

[FIG. **1**]

(a) is a top view schematically showing a structure of a discharge lamp **100** according to Embodiment **1**, and **(b)** is a side view schematically showing the structure of the discharge lamp **100**. **(c)** is a cross-sectional view showing the cross section taken along the line c-c′ in **(a)**, and **(d)** is a enlarged view schematically showing the shape of an end face of a metal foil **24**.

[FIG. **2**]

An enlarged cross-sectional view showing a constricted part of a sealing portion.

[FIG. **3**]

(a) through **(c)** are cross-sectional views for

illustrating process steps of a method for producing the discharge lamp **100** of Embodiment **1**.

[FIG. **4**]

A cross-sectional view for illustrating a process step of a method for producing a discharge lamp **200** of Embodiment **1**.

[FIG. **5**]

(a) is a top view schematically showing a structure of a discharge lamp **300** according to Embodiment **2**, **(b)** is a side view schematically showing the structure of the discharge lamp **200**, and **(c)** is a cross-sectional view showing the cross section taken along the line c-c′ in **(a)**.

[FIG. **6**]

A cross-sectional view illustrating a process step of a method for producing the discharge lamp **300** of Embodiment **2**.

[FIG. **7**]

A cross-sectional view schematically showing a structure of a lamp unit **500** according to Embodiment **3**.

[FIG. **8**]

(a) is a top view schematically showing a structure of a conventional discharge lamp **1000**, **(b)** is a side view schematically showing the structure of the discharge lamp **1000**. **(c)** is a cross-sectional view showing the cross-section taken along the line c-c′ in **(a)**.

[FIG. **9**]

(a) through **(c)** are drawings for explaining the problems of the conventional discharge lamp **1000**.

[Explanation of the Reference Characters]

10 luminous bulb

12 and **12′** electrode (W electrode)

14 coil

15 discharge space (inside space)

16 electrode rod

17 Mo rod

18 luminous material (mercury)

20 and **20′** sealing portion

22 glass portion

24 metal foil (Mo foil)

26 constricted part

28 oblate cross-sectional part

30 external lead

32 junction (welded portion)

40 and **40′** internal stress

44 grinder

45 crack

50 burner

55 lamp base

60 reflecting mirror

62 opening for a lead wire

65 lead wire

100, 200, and 300 discharge lamp

500 lamp unit

110 luminous bulb

112 and **112'** W electrode

114 coil

115 discharge space (inside space)

116 electrode rod

118 luminous material (mercury)

120 and **120'** sealing portion

122 glass portion

124 Mo foil

130 external lead

1000 ultra high-pressure mercury lamp

[Name of the Document] Abstract

[Abstract]

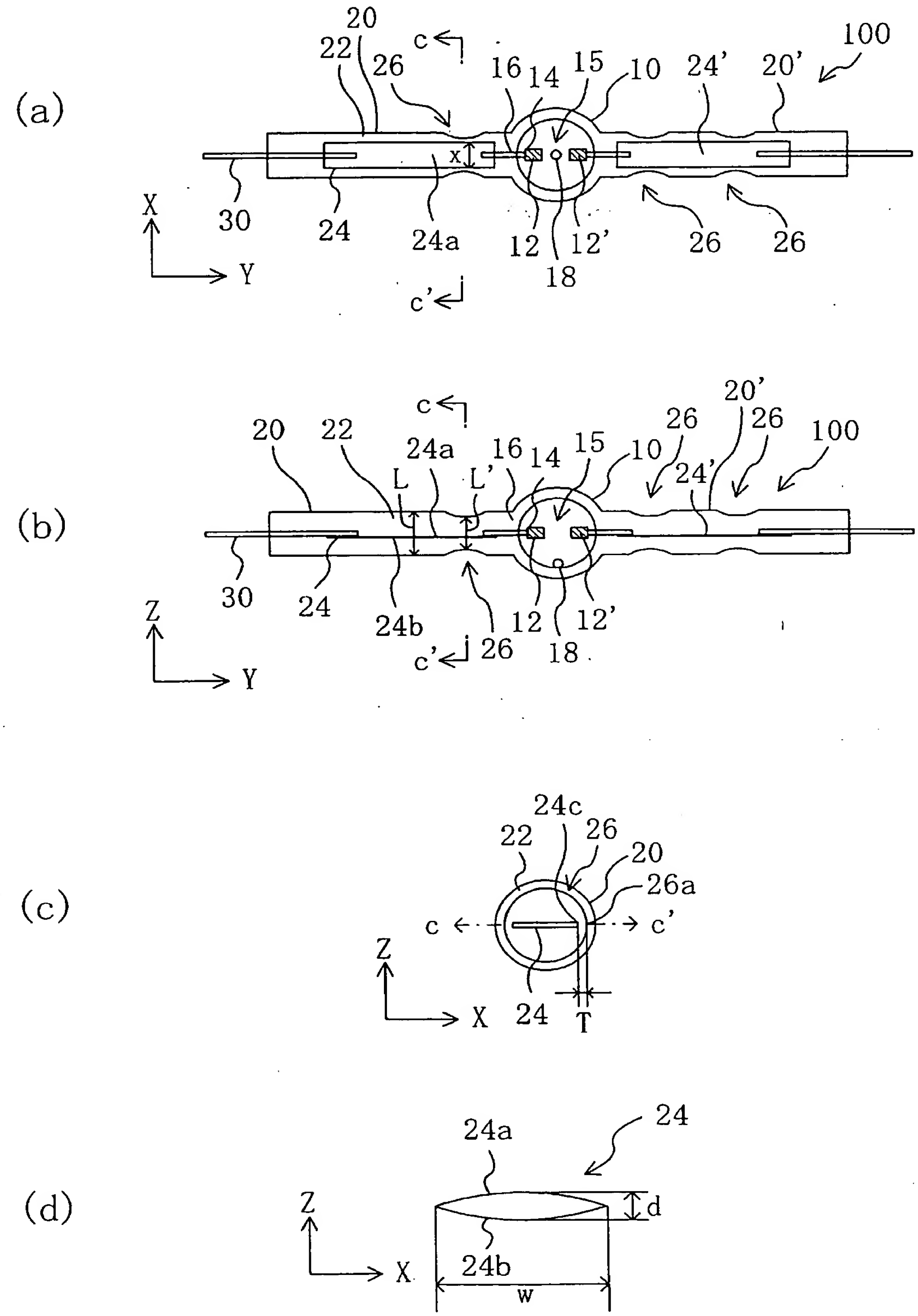
[Purpose] To provide a discharge lamp that can maintain a sealing structure of sealing portions for a long time, resulting in prolonged lifetime of the lamp.

[Solution] A discharge lamp **100** includes: a luminous bulb **10** within an inside space **15** of which a luminous material **18** is enclosed and a pair of electrodes **12** and **12'** are opposed to each other; and a pair of sealing portions **20** and **20'** for sealing a pair of metal foils **24** and **24'** electrically connected to the pair of electrodes **12** and **12'**, respectively, wherein at least one sealing portion **20** of the pair of sealing portions **20** and **20'** is provided with at least one constricted part **26** (with a length **L'**) whose length **L** in a thickness direction of the metal foil **24** in the sealing portion **20** is smaller compared with other parts in the sealing portion **20**.

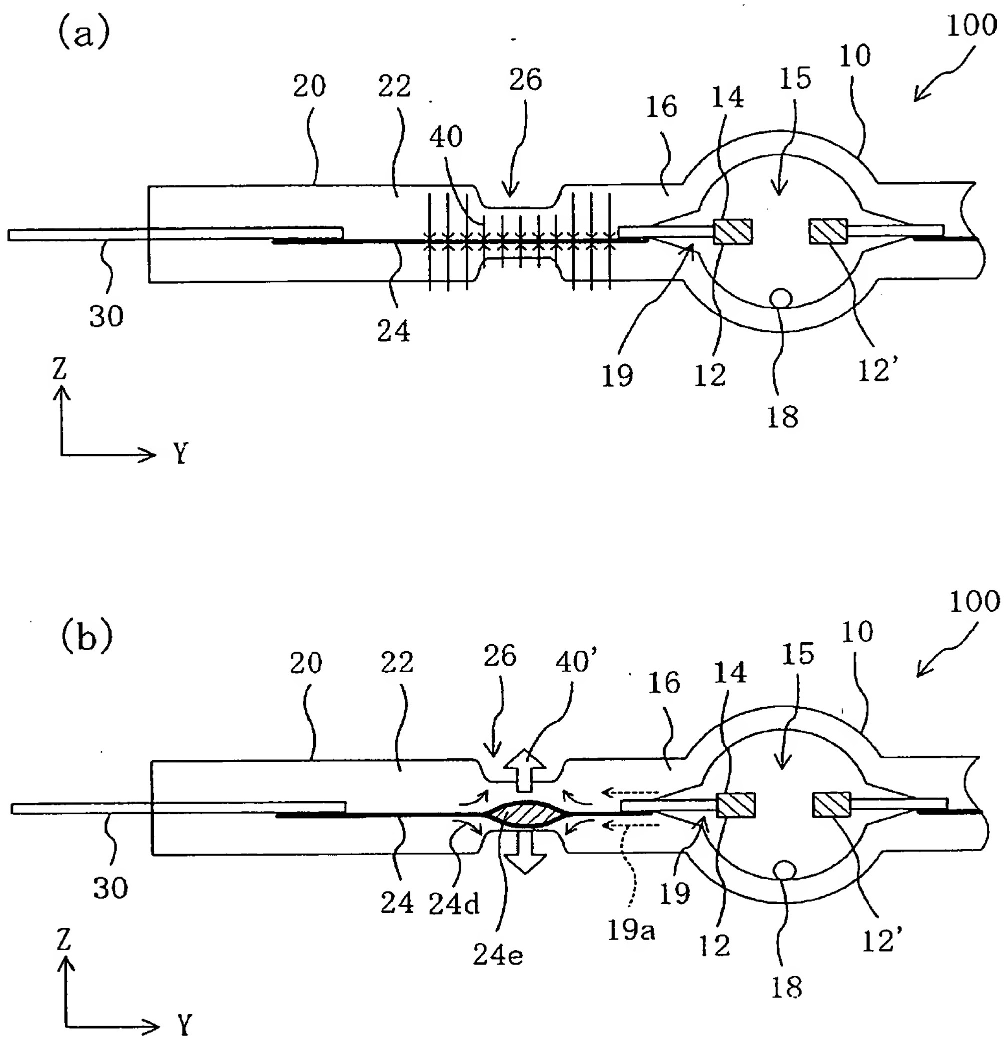
[Selected Figure] FIG. **1**

【書類名】　図面 [Name of Document] Drawings

【図１】 Fig. 1

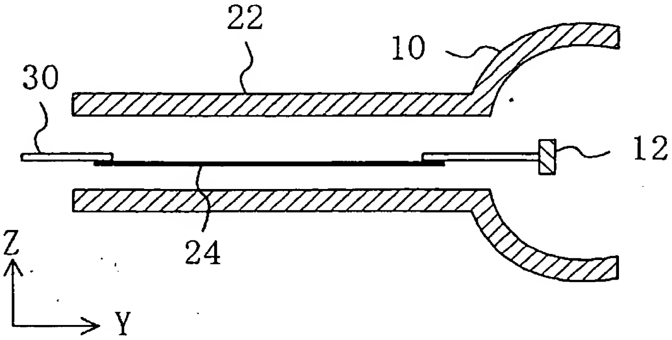


【図２】 Fig.2

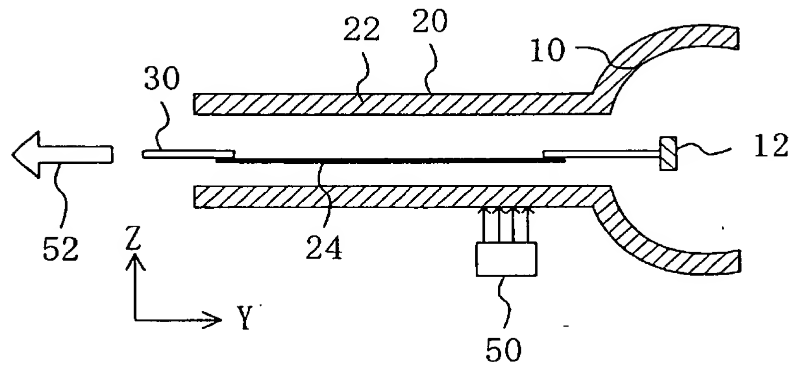

(a)
100
10
15
14
16
26
22
20
40
30
24
19
12
18
12'
Z
Y
(b)
100
10
15
14
16
40'
26
22
20
30
24
24d
24e
19a
19
12
18
12'
Z
Y

【図３】Fig.3

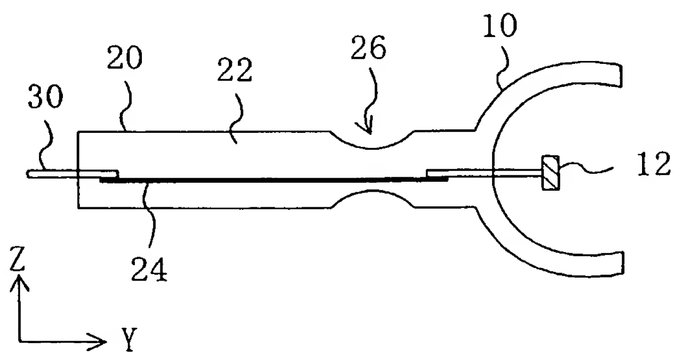
(a)



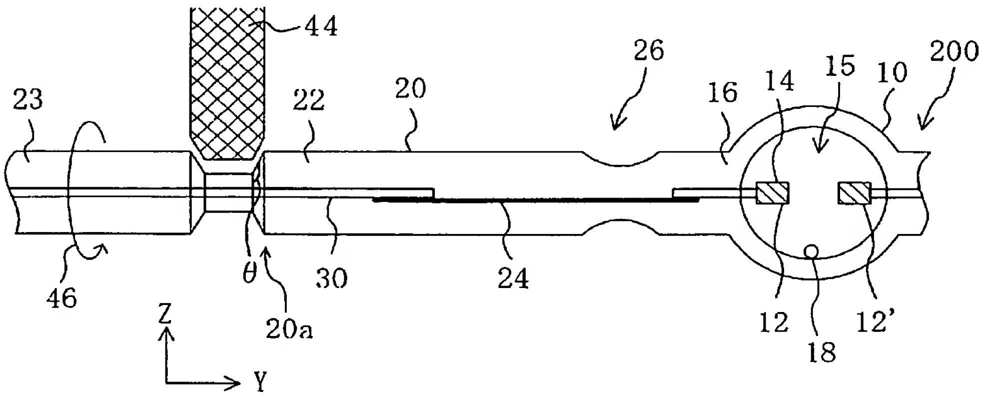
(b)



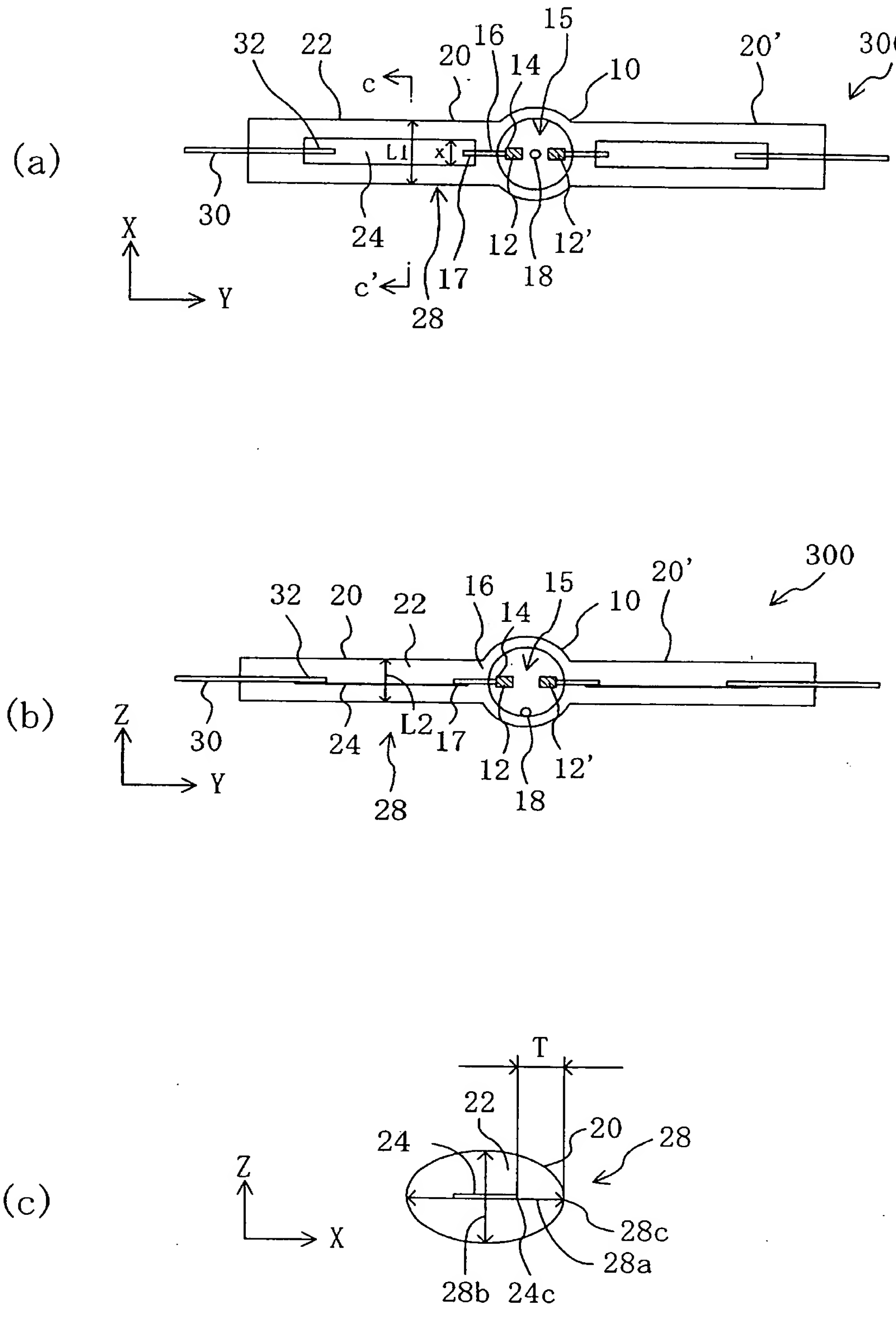
(c)



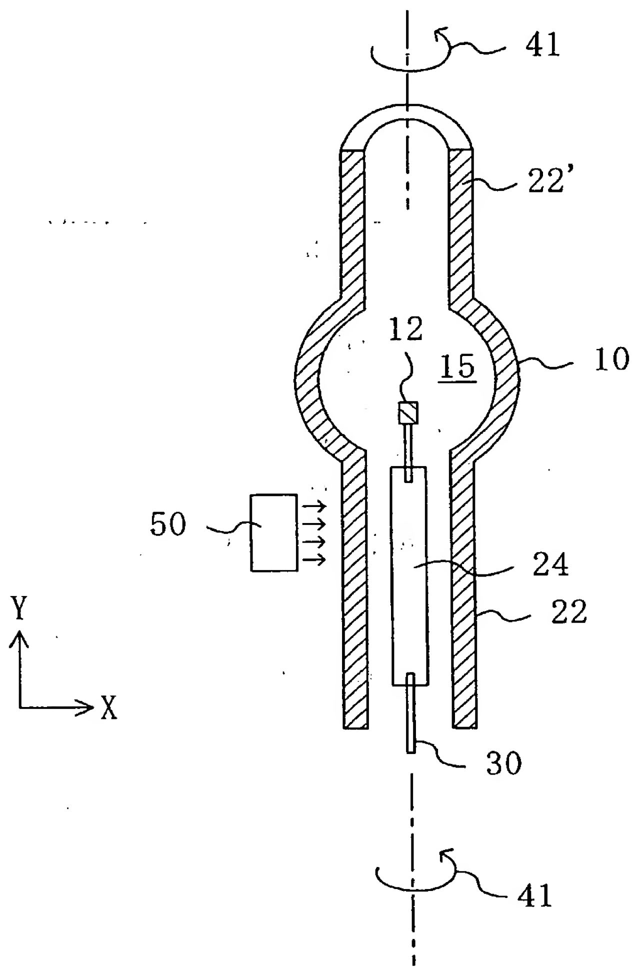
【図４】 Fig. 4



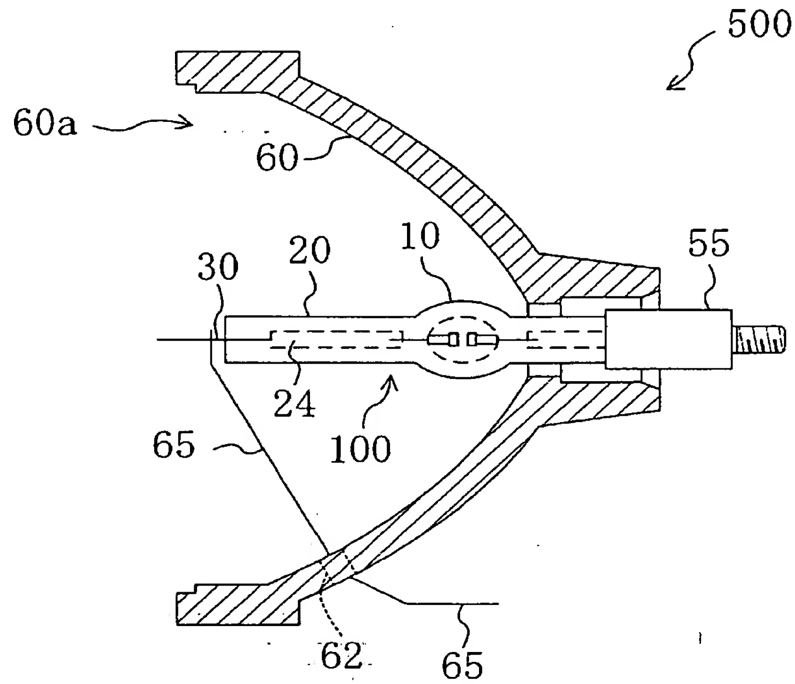
【図５】Fig. 5


(a)
32
22
20
16
15
14
10
20'
300
c
c'
L1
x
30
24
28
17
12
18
12'
X
Y
(b)
32
20
22
16
15
14
10
20'
300
30
24
L2
17
12
18
12'
28
Z
Y
(c)
T
22
20
24
28
28c
28a
28b
24c
Z
X

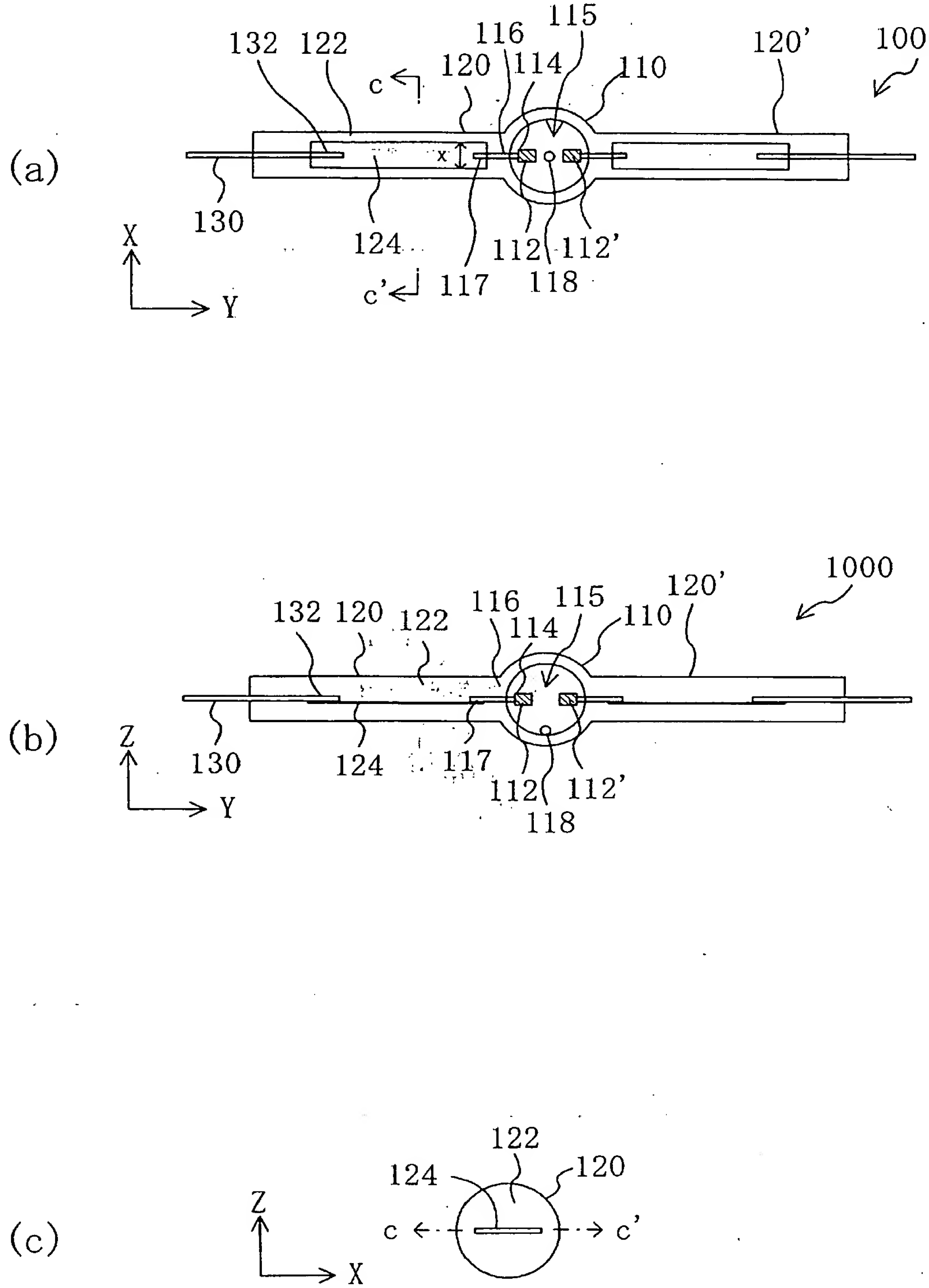
【図６】Fig.6



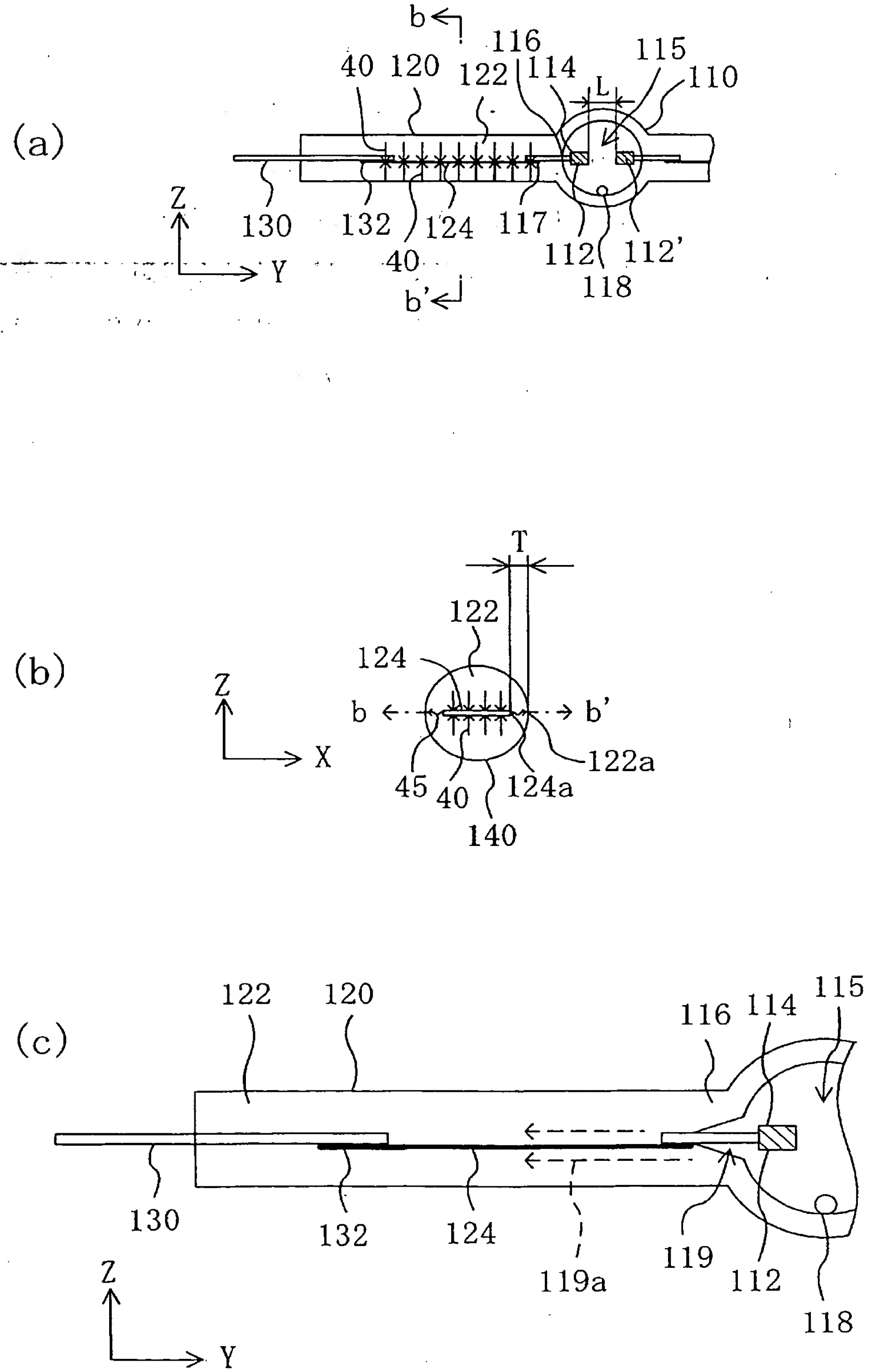
【図７】Fig. 7



【図８】 Fig-8


(a)
132
122
c
120
116
114
115
110
120’
1000
x
130
124
117
c’
112
112’
118
X
Y
(b)
132
120
122
116
114
115
110
120’
1000
130
124
117
112
112’
118
Z
Y
(c)
124
122
120
c
c’
Z
X

【図９】 Fig. 9


(a)
b
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120
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116
114
115
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110
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132
124
117
40
112
112’
118
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Y
(b)
T
122
124
b
b’
Z
X
45
40
124a
122a
140
(c)
122
120
116
114
115
130
132
124
119a
119
112
118
Z
Y